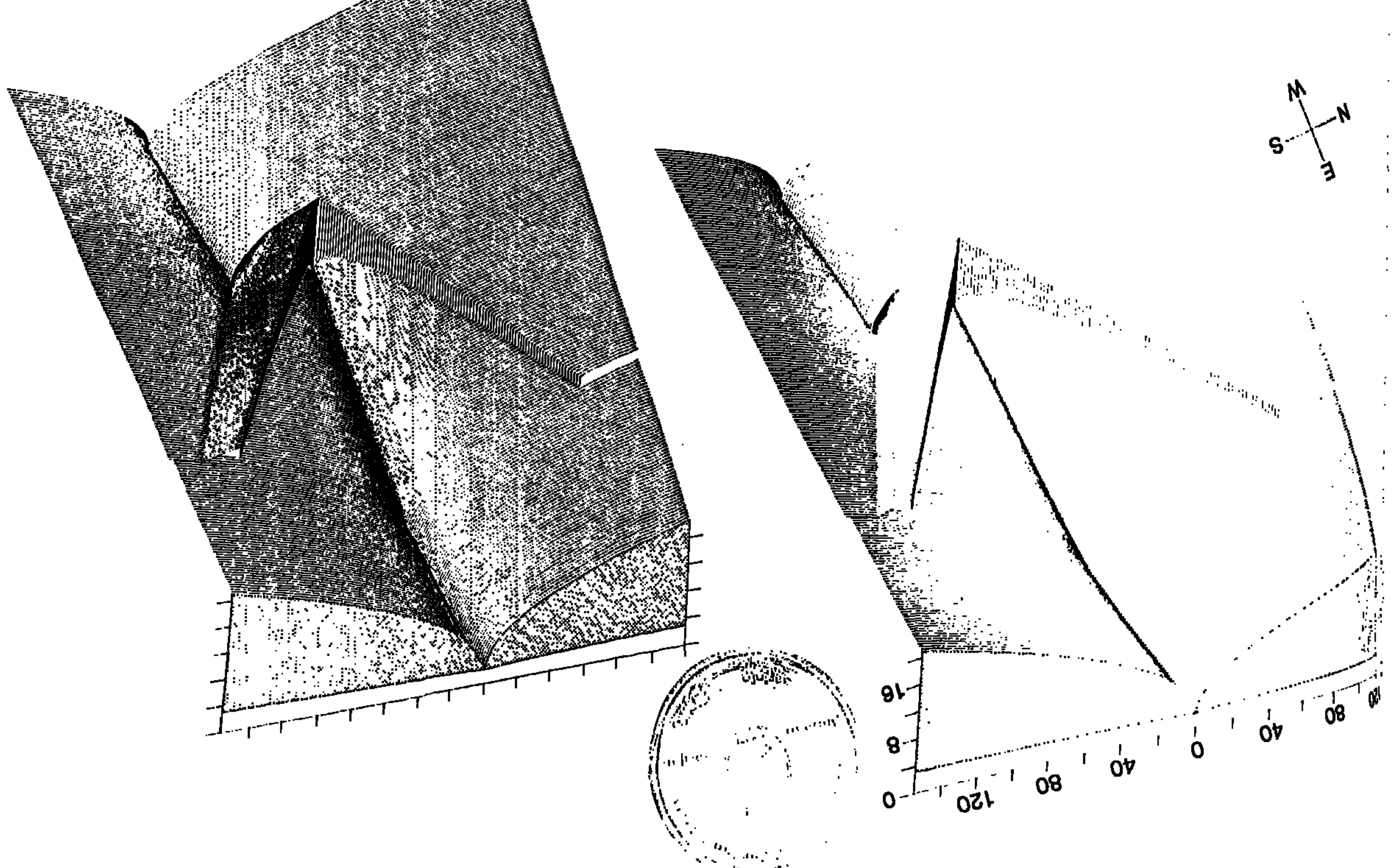


EOS, Transactions, American Geophysical Union
Vol. 64, No. 13, Pages 121–128
March 29, 1983

News

Synchrotron Uses

The geological and materials sciences have a number of common interests and interfaces, according to a report recently issued by the National Academy Press. Entitled *Fostering Increased Cooperation Between the Geological and Material Sciences*, the report provides a relatively low-key comparison of areas of common ground between the two sciences; it identifies no major issues of disagreement and thus has no axes to grind. Instead, the report is a short, soft-sell discussion of the burgeoning revolutions taking place in the more applied sectors of the geological and condensed matter or solid-state sciences. The material sciences are receiving a wealth of experience with highly complex mineralogical and geological materials and advances in the applications of analytical techniques that had been originated by solid-state scientists for the study of metals and single compounds. In turn, the earth sciences are receiving new techniques and theories from the material sciences.

According to the report, both fields of applied science need better lines of intercommunication to foster more effective interaction. An example of this need is noted in the report; it centers on the common requirement of both the geological and the material sciences for a higher intensity energy source than is now available to advance the analysis of condensed matter. Synchrotron radiation sources appear to be central in meeting this requirement.

It is noteworthy that in another study by the National Academy of Sciences, the so-called 'Lynch Report' of the Solid-State Sciences Committee (*Physics Today*, February 1983), it was concluded that, 'By 1985, . . . demand for x-ray and UV (synchrotron) beams will exceed the additional supply that would be available if unused ports on current machines were developed.' Synchrotron facilities at Stanford University, the University of Wisconsin, Cornell University, and at Brookhaven National Laboratory are being constructed or modified to meet the needs of new, exciting, materials analysis research. Originally only a side advantage that was relatively unused in synchrotron facilities, the high intensity white radiation released as a secondary product in the acceleration of electrons has now taken precedence over the particle-physics experiments for which the facilities were constructed. Rather special instrumentation is needed to exploit the 'free' white radiation, and new generations of synchrotrons are being planned for the purpose.

In older, 'first generation' synchrotrons the primary electron beam is held in a circular path by means of dipole magnets placed in precise locations along the accelerator ring. The intensity of the high-energy beam of radiation that is released as the electrons are accelerated around a circular path can be increased by several orders of magnitude by new concepts of magnetic-field insertion devices that are called 'wigglers' or 'undulators.' These devices have a large number of weak dipoles or a smaller number of strong dipoles. Depending on the design, high intensity beams of broad or narrow wavelength spectra can be created. A number of problems with these devices, such as overheating caused by the large energy densities, have yet to be solved. The insertion devices are mostly still in the design and construction stages, awaiting testing. Research areas noted in the Lynch Report are SEXAFS (surface X ray absorption fine structure), X ray diffraction and scattering, and photoemission spectroscopy. The sort of problems to be investigated with these ultra-high-intensity beams include the study of short-time (nanosecond) phenomena, two-dimensional structures, and surface physics. The relatively unexplored field of megabar high-pressure experiments may yield a wealth of new materials that are amenable to study by synchrotron radiation beams.

Of relevance to the renewed interest in the study of materials properties is the recent news of the new National Center for Advanced Materials (NCAM) proposed as a major new direction for the Lawrence Berkeley Laboratory in California. According to one report, the planned laboratory 'comes with a strong endorsement from White House science advisor George Kenworth, and it is a centerpiece of the proposed 1984 budget for the Department of Energy (DOE) general sciences program.' (*Nature*, February 10, 1983). In another recent report it is noted that, 'A synchrotron radiation light source is the centerpiece for the National Center for Advanced Materials at the Lawrence Berkeley Laboratory' (*Science*, February 18, 1983). The costs to DOE for NCAM will be a total of $263.8 million, of which $138.9 million would be for construction of facilities. The new, third-generation synchrotron will take 6 years to build, at a cost of $84 million. As a subset, $13.8 million is to be allocated to the Stanford University Synchrotron Radiation Laboratory to experiment with the problems of unusually intense X ray beams.

The NCAM will include three laboratories, one for Surface Science and Catalysis, one for Advanced Material Synthesis, and one for Advanced Device Concepts. Perhaps most interesting to the geology-materials science interface is the Advanced Materials Synthesis Laboratory in which theoretical and experimental studies will be done of phase transitions and materials at high pressures. Central to the three laboratories missions will be the new-generation synchrotron Advanced Light Source (ALS), which is to produce a beam brightness (energy density per unit area) some 10^4 times greater than existing sources. According to the designers, 'The brightness of the synchrotron radiation from the ALS will not be entirely due to the use of insertion devices. Another important feature, reports *Science*, is the storing of a circulating electron beam (1.3 billion eV) with a very small emittance.' The new light source will overcome problems of beam stability inherent in the older accelerators by focusing to a stable point source.

The National Academy report of the Committee on Geological and Materials Sciences noted that the number of people working on geological materials was less, by one or two factors of ten, than the number working in the materials sciences. Federal agencies, it was noted, spent over $1 billion on materials R&D in 1980. Geologists have had notable successes in the fields of extractive metallurgy and other materials sciences areas; according to the report, examples in which information has flowed to, rather than, as in so many other cases, from the materials sciences include phase equilibrium, isotope and trace element analysis, major element analysis by the electron microprobe, and high-pressure, high-temperature research.—*PMB*

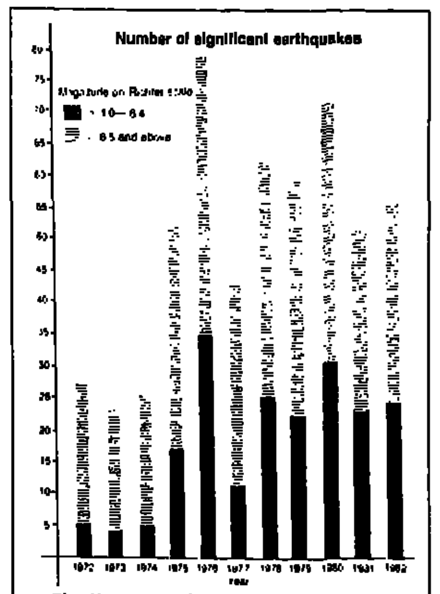
Earthquakes Up Worldwide in 1982

Fifty-six 'significant earthquakes' were recorded in 1982, up from the 1981 tally of 51, according to a recent report from the U.S. Geological Survey (USGS). In addition, in the United States there were 33 more 'felt' earthquakes in 1982 than in 1981. The number of lives lost worldwide to earthquakes, however, dropped by one-third. A significant earthquake is defined as one that registers 6.5 or above on the Richter scale or one of smaller magnitude that causes casualties or considerable damage. Felt earthquakes are nonsignificant quakes that are reported as being felt by people. The data are compiled by the USGS from 3,000 seismograph stations around the world.

In the United States in 1982 only one significant earthquake occurred, striking on January 25; this was the lowest number recorded since 1974, when none occurred. The 1982 event registered 6.5 and was centered in the Fox Islands in the Aleutians; there were no reports of casualties or damages.

The strongest earthquake of 1982, measured at 7.7, hit the Tonga Islands region of the South Pacific on December 19 without causing damage or casualties, according to Waverly Person, a geophysicist at the USGS National Earthquake Information Service. It was among a total of 10 major earthquakes (registering 7.0 to 7.9) recorded worldwide. For the second consecutive year no great earthquakes (registering 8.0 or more) occurred; the last such event was a magnitude 8.0 quake recorded on July 17, 1980, in the Santa Cruz Islands region of the South Pacific. The long-term average of earthquakes of magnitude 7.0 and over is 19 per year.

The most devastating earthquake of 1982 occurred in North Yemen, located on the Arabian Peninsula. Registering a magnitude of 6.0, it killed 2,800 people, injured another 1,500, left more than 700,000 homeless, and destroyed or extensively damaged 300 villages. The second deadliest jolted the Hindu Kush region of Afghanistan with a magnitude 6.5. Reported deaths totalled 450, with many others injured. The zone of damage stretched into Tajikistan in the Soviet Union. In addition, a magnitude 7.0 quake that struck El Salvador in Central America on June 19 claimed 40 lives.



Significant earthquakes throughout the world. A significant earthquake is defined as one that registers 6.5 or above on the Richter scale or one of smaller magnitude that causes casualties or considerable damage. The smallest significant earthquake occurring in the period charted above measured 4.2. Data courtesy of USGS; data charted by Mario E. Godinez; chart drafted by Dae Sung Kim.

Person said the known death toll from earthquakes in 1982 was 3,338, about one-third fewer people than were reported killed in 1981; most of the deaths in 1981 are attributed to two strong quakes that hit Iran. On the long-term average, 10,000 earthquake-related deaths are expected each year. Notably, no earthquake-related deaths have been reported in the United States since 1975.

In 1982, the USGS received 404 reports of felt earthquakes in the United States. The strongest to occur in the coterminous 48 states was a magnitude 5.5 tremor that rumbled along the California-Nevada border south of Hawthorne, Nev., and southeast of Mono Lake, Calif., on September 24.

Once again, Hawaii led other states with 137 felt earthquakes, followed by California with 108 and Alaska with 44. The other states reporting felt quakes and the number of reports for each were Arkansas 14; Idaho 11; Nevada 10; Maine 8; New Hampshire 7; Connecticut, New Mexico, and Washington 6 each; Vermont 5; Massachusetts and Montana 4 each; Arizona, Colorado, Georgia, Tennessee, and Texas 3 each; Alabama, New York, South Carolina, South Dakota, and Utah 2 each; and Iowa, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, North Carolina, Oklahoma, and Pennsylvania 1 each.

Person said the USGS normally records between 6,000 and 7,000 earthquakes worldwide each year that range in magnitude from 3 to 8 or more on the Richter scale. Several million more earthquakes may occur, he said, but most are so small or happen in such remote areas that they are not detected even by the most sensitive instruments in the worldwide seismograph network.—*MEG*

Salton Sea Minerals

The long-held notion that precious metals, minerals, and other useful substances can be extracted from natural waters is starting to become realized at several locations of geothermal brines. In a recent study by A. Maimoni of the Lawrence Livermore National Laboratory it was determined that there is a high potential for minerals recovery from the hot brines of a 1000-MWe geothermal power station at the Salton Sea geothermal field in southern California. The study estimated that the revenue from the minerals could substantially exceed that from the power station (*Geothermics, 11*, 239–258, 1982).

According to the study, 'A 1000-MWe power plant could recover 14-31% of the U.S. demand for manganese.' In the example of lithium production, such a geothermal plant could produce 5–10 times the annual world output of lithium. Large quantities of lead and zinc could be extracted, as well as significant amounts of gold, platinum, and silver. The chemical composition of the brines is incredibly complex, however, for reasons not currently understood.

In pilot-plant studies at the Salton Sea, there have been numerous difficulties related to the precipitation of silica, corrosion, and other factors, and thus new recovery techniques will be required. The Lawrence Livermore study suggests that a chemical cementation process, in which metallic iron is used to cause precipitation of dissolved metals, may be the most economical.

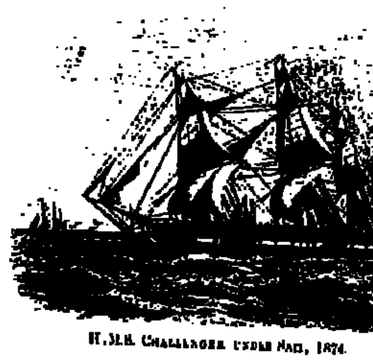
In the cementation extraction technique, spent brines are processed through a metallurgical recovery system, and then the brine is reinjected. At the well head, finely divided iron is introduced into the brine to act as a nucleation source for the precipitation of sulfides and precious metals. Hydrochloric acid is added to the brines as they are passed through fluidized beds and various separation stages.

Silica control is absolutely necessary in the metal extraction process. The deposition of silica-rich scale is substantial during any equipment operation involving the brines, and indeed scale has been a major negative factor in the development of geothermal energy in the Salton Sea area. Among other examples, the Magmamax No. 1 well in the area had recorded scaling rates as high as 0.002 cm/h. The scales contain much more than silica, however; a 3-month test sample, in which 5–7 tonnes of scale were collected, contained approximately 20% copper plus a concentration of precious metals amounting to several kilograms of silver and about 0.003 kg of gold per tonne.

In the Lawrence Livermore study, scale was reduced by addition of hydrochloric acid to lower the pH to a value of about 1.5. Suspended solids in the brines could be reduced to zero, but steel corrosion rates were of concern. Corrosion rates vary with location, pH, temperature, and other factors. Testing showed that the rates of corrosion were not greatly harmful, however, ranging from a few thousandths to a few hundredths of a centimeter per year in steel pipe specimens.

The outline of a successful geothermal power and minerals recovery plant in the Salton Sea area is as follows. The plant would operate 75% of the time for a total of 6570 operating hours per year. A 90% recovery rate for the mineral values in the brines was estimated before the brines were re-injected into the ground. The power plant would yield a net power of 22 Wh/kg of brine, corresponding to a brine flow rate of 45 million kg/h. At six cents per kilowatt-hour, the power plant value would amount to $394 million per year. The estimated recovery would involve 48 tonnes per year of SiO_2, 11 tonnes per year of NH_3, 28 tonnes per year of Si, 136 tonnes per year of Mn, 102 tonnes per year of Fe, and lesser amounts of Zn, Sn, Pb, Se, Ag, Au, and Pt. These estimates are not highly accurate, considering the variability of the brines, but they indicate a real potential.—*PMB*

The Oceanography Report



H.M.S. CHALLENGER [illegible] 1874.

The Oceanography Report
The focal point for physical, chemical, geological, and biological oceanographers.

Associate Editor: Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, New York, 10964 (telephone 914/359-2900, ext. 325)

Distribution of Elements in Sea Water

M. S. Quinby-Hunt and K. K. Turekian

The purpose of this report is to provide a basis for predicting the composition of elements at any depth or location in the world oceans. Our aim is not to assess the importance of variations in elemental concentrations but only to provide a method of estimating them. The method, however, provides no entry into the problem of estimating the effects of local releases from sediments or of human activity.

The salinity of the open ocean ranges between 33‰ and 38‰. *Dittmar* [1884] showed that despite this variation in total salt concentration the proportions of the different ions making up most of the salt content were remarkably constant. In that sense these ions are identified as being 'conservative'; that is, their variation is ascribed exclusively to the addition or subtraction of pure water to a saline solution of fixed elemental proportions. The concentrations of certain trace elements also have been shown to correlate with chlorinity within analytical errors and these too can be classified as behaving conservatively.

It was early realized, by noting the distribution of high productivity regions of the ocean, that certain elements (phosphorus, nitrogen, and silicon) are not conservative; surface waters are generally depleted in these elements and deep waters have higher concentrations than overlying surface waters. These are called the 'nutrient' elements. Any other element behaving in a similar way could also be so designated. The fact that the distribution of certain trace elements might resemble that of the nutrients was not easily demonstrable until a few years ago because of analytical limitations. There were, however, intimations of this relationship [*Schutz and Turekian*, 1965*a*, *b*], and the concept was proposed as reasonable, although with no clear cut examples, by *Goldberg et al.* [1971]. It was finally demonstrated for Sr [*Brass and Turekian*, 1974] and Cd [*Knauer and Martin*, 1973] and has since been a well-established observation for many trace elements.

The dissolved gases have a much more complex distribution. Initially, the levels are determined by the solubility of atmospheric gases in surface water and by bubble trapping. In principle the concentration of each gaseous component could be determined by the temperature of the water in contact with the atmosphere and the measured relative abundances of the gases in the atmosphere, although corrections must be made for bubble trapping. Supersaturation can occur with heating of the water as it sinks and moves away from the site of a cold surface injection. A much more marked effect is observed for biologically processed gases which change in concentration as the result of metabolism. Thus oxygen is produced by photosynthesis in surface water and used up during net respiration at depth. Other gases similarly affected to some degree are N_2, CO_2, N_2O, H_2S, H_2 and CO.

The open ocean has been impacted by man's activities. This is clearly seen by the presence of bomb-produced nuclides such as ^{90}Sr, ^{137}Cs, ^{3}H, ^{14}C(bomb) and plutonium. In addition, at least one element, Pb, has been clearly shown to owe its distribution to anthropogenic inputs. The distribution of these nuclides in the ocean is controlled by supply from the atmosphere and from coastal sources, thus generally showing patterns of diminishing concentration with depth.

Fluxes of some nuclides from the ocean boundaries can significantly modify the distribution pattern of these nuclides. The most striking of these is primitive ^{3}He degassing from the earth's interior at oceanic spreading centers [*Craig and Lupton*, 1981]. It has been shown that Mn correlates with ^{3}He in such areas [*Weiss*, 1977]. Manganese concentrations are also high at shallow depths near the continental margin, indicating release from reducing sediments there [*Landing and Bruland*, 1980]. Copper is released from the deep ocean bottom by the degradation of carrier phases at the interface [*Boyle et al.*, 1977].

Finally, removal processes characteristic of the ocean–bottom interface such as particle resuspension and manganese precipitation also influence the distribution patterns of the elements. This influence has been shown for ^{210}Pb produced from the decay of ^{226}Ra [*Craig et al.*, 1974; *Nozaki et al.*, 1980] but has not yet been demonstrated for the trace metals in the deep sea.

All the above relationships act to determine the element composition of seawater as a function of location and depth. Aside from the elements showing strong boundary effects or those with strong anthropogenic signals, the distribution patterns for trace elements are approximated by (1) behavior as a conservative element or (2) behavior as a nutrient element. We have reviewed the literature reporting distributions of elements in seawater and the correlations they exhibit with conservative or nutrient components. We have assigned some elements to a correlation category based on the data available, although detailed profiles have not been published.

Table 1 includes the reported behavior of each element. For conservative elements, the relation to chlorinity (CL) is reported. For nutrient-correlated elements the correlation equation and the correlation coefficients are given. Table 2 summarizes the best available data on the concentrations of the elements in seawater (in order of atomic number). Data have been published in a variety of units; here, concentrations of elements other than nutrients and gases are expressed as milligrams per kilogram, micrograms per kilogram, or nanograms per kilogram depending on the concentration. The nutrients and gases are given as micromoles per kilogram. In Table 2, surface or near-surface concentrations and a concentration near 1000 m in the Pacific Ocean are reported where possible. A mean ocean concentration has been calculated where possible using correlation expressions found in Table 1, a salinity of 35‰, and nitrate, phosphate, and silicate concentrations of 30, 2, and 110 μmol/kg (based on *Bainbridge* [1979a, b, c]), respectively.

The concentrations of some of the members of the ^{238}U, ^{235}U, and ^{232}Th decay chains (^{234}Th, ^{234}U, ^{230}Th, ^{226}Ra, ^{222}Rn, ^{210}Pb, ^{210}Po, ^{231}Pa, ^{228}Ra, ^{228}Th) have been extensively studied recently, in large part as a consequence of the GEOSECS program and its successors. Most of the papers dealing with the distributions of these radionuclides are published in *Earth and Planetary Science Letters*, *Deep-Sea Research*, and *Journal of Geophysical Research*.

TABLE 1. [illegible]

Atomic Number	Element	Species	[illegible]	[illegible]	Reference
1	Hydrogen	H_2	[illegible]		
2	Helium		[illegible]	[illegible]	[illegible]
3	Lithium		[illegible]		
4	Beryllium		[illegible]	[illegible]	[illegible]
5	Boron	Inorganic boron	[illegible]	[illegible]	[illegible]
6	Carbon	[illegible]	[illegible]		
7	Nitrogen	[illegible]	[illegible]		
8	Oxygen	Dissolved O_2	[illegible]		
9	Fluorine		[illegible]		
10	Neon		[illegible]	[illegible]	[illegible]
11	Sodium		[illegible]		
12	Magnesium		[illegible]	[illegible]	[illegible]
13	Aluminum				
14	Silicon	Silicate	[illegible]		[illegible]
15	Phosphorus	Phosphate	[illegible]	[illegible]	[illegible]
16	Sulfur	Sulfate	[illegible]		
17	Chlorine	Chloride	[illegible]		
18	Argon		[illegible]		[illegible]
19	Potassium		[illegible]	[illegible]	[illegible]
20	Calcium		[illegible]	[illegible]	[illegible]
21	Scandium				
22	Titanium				
23	Vanadium		[illegible]	[illegible]	[illegible]
24	Chromium		[illegible]	[illegible]	[illegible]
25	Manganese		[illegible]		[illegible]
26	Iron		[illegible]		[illegible]
27	Cobalt		[illegible]		[illegible]
28	Nickel		Nutrient-correlated	[illegible]	[illegible]
29	Copper		[illegible]		[illegible]
30	Zinc		Nutrient-correlated	[illegible]	[illegible]
31	Gallium		[illegible]	[illegible]	[illegible]
32	Germanium		[illegible]		
33	Arsenic	As(V)	[illegible]	[illegible]	[illegible]
34	Selenium	Se(VI)	[illegible]	[illegible]	[illegible]
		Se(IV)	[illegible]	[illegible]	
		Se(VI)	[illegible]	[illegible]	
35	Bromine	Bromide	Conservative	[illegible]	[illegible]
36	Krypton		[illegible]		
37	Rubidium		[illegible]	[illegible]	[illegible]
38	Strontium		[illegible]	[illegible]	[illegible]
39	Yttrium				
40	Zirconium				
41	Niobium				
42	Molybdenum		Conservative	[illegible]	[illegible]
44	Ruthenium				
45	Rhodium				
46	Palladium				
47	Silver				
48	Cadmium		Nutrient-correlated, phosphate	[illegible]	[illegible]
49	Indium				
50	Tin				
51	Antimony		[illegible]	[illegible]	[illegible]
52	Tellurium				
53	Iodine	Iodate	[illegible]	[illegible]	[illegible]
54	Xenon		[illegible]		
55	Cesium		[illegible]	[illegible]	[illegible]
56	Barium		[illegible]	[illegible]	[illegible]
57–71	Lanthanum and the Lanthanides		[illegible]		[illegible]
72	Hafnium				
73	Tantalum				
74	Tungsten				
75	Rhenium				
76	Osmium				
77	Iridium				
78	Platinum				
79	Gold				
80	Mercury				
81	Thallium		[illegible]	[illegible]	[illegible]
82	Lead		Non-conservative, anthropogenic		[illegible]
83	Bismuth				
84	Polonium		See text		
85	(Astatine)				
86	Radon		See text		
87	(Francium)				
88	Radium		See text		
89	Actinium		See text		
90	Thorium				
91	Protactinium				
92	Uranium		Conservative	$U/Cl = 1.7 \times 10^{-7}$	*Turekian and Chan* [1971]

The relationship to chlorinity is mass to mass. S = salinity. Nutrient concentrations are in micromoles per kilogram.

References

Andreae, M. O., Arsenic speciation in seawater and interstitial waters: The biological-chemical interactions on the chemistry of a trace element, *Limnol. Oceanogr.*, *24*, 440–452, 1979.

Bainbridge, A. E., GEOSECS Pacific first hydrographic data report, 1st ed., August 22, 1973, to June 10, 1974, R/V *Melville*, *Publ. 32*, GEOSECS Operations Group, Scripps Institution of Oceanography, La Jolla, Calif., 1979*a*.

Bainbridge, A. E., GEOSECS Atlantic final hydrographic data report, July 21, 1972 to April 1, 1973, R/V *Knorr*, *Publ. 30*, GEOSECS Operations Group, Scripps Institution of Oceanography, La Jolla, Calif., 1979*b*.

Bainbridge, A. E., Hydrographic Report for GEOSECS Indian Ocean Expedition (INDOMED, Legs 3–7), *Publ. 145*, 2nd ed. GEOSECS Operations Group, Scripps Institution of Oceanography, La Jolla, Calif., 1979*c*.

Bewers, J. M., G. R. Miller, D. R. Kester, and T. B. Warner, Rapid changes in the fluoride to chlorinity ratio south of Greenland, *Nature*, *242*, 142–143, 1973.

Bieri, R. H., M. Koide, E. D. Goldberg, Noble gas contents of marine waters, *Earth Planet. Sci. Lett.*, *4*, 329–340, 1968.

Boyle, E. A., F. R. Sclater, and J. M. Edmond, The distribution of dissolved copper in the pacific, *Earth Planet. Sci. Lett.*, *37*, 38–54, 1977.

Brass, G. W., and K. K. Turekian, Strontium distribution in GEOSECS oceanic profiles, *Earth Planet. Sci. Lett.*, *23*, 141–148, 1974.

Brewer, P. G., D. W. Spencer, and D. E. Robertson, Trace element profiles from the GEOSECS II test station in the Sargasso Sea, *Earth Planet. Sci. Lett.*, *16*, 111–116, 1972.

Broecker, W. S., and T. Takahashi, The relationship between lysocline depth and *in situ* carbonate ion concentration, *Deep-Sea Res.*, *25*, 65–95, 1978.

Brooks, R. R., The use of ion-exchange enrichment in the determination of trace elements in sea water, *Analyst*, *85*, 745–749, 1960.

Bruland, K. W., Oceanographic distributions of cadmium, zinc, nickel and copper in the north Pacific, *Earth Planet. Sci. Lett.*, *47*, 176–198, 1980.

Burton, J. D., F. Culkin and J. P. Riley, The abundance of gallium and germanium in terrestrial materials, *Geochim. Cosmochim. Acta*, *16*, 151–180, 1959.

Byrd, J. T., and M. O. Andreae, Tin and methyltin species in seawater: Concentrations and fluxes, *Science*, *218*, 565–569, 1982.

Carlisle, D. E., and L. G. Hummerstone, Niobium in sea water, *Nature*, *181*, 1002, 1958.

Carpenter, J. H., and M. E. Mannella, Magnesium to chlorinity ratios in seawater, *J. Geophys. Res.*, *78*, 3621–3626, 1973.

Chan, K. M., and J. P. Riley, Determination of tungsten in silicates and natural waters, *Anal. Chim. Acta*, *39*, 103–113, 1967.

Chan, L. H., J. M. Edmond, R. F. Stallard, W. S. Broecker, Y. C. Chung, R. F. Weiss, and T. L. Ku, Radium and barium at Geosecs station in the Atlantic and Pacific, *Earth Planet. Sci. Lett.*, *32*, 258–267, 1976.

Clarke, W. B., M. A. Beg, and H. Craig, Excess helium-3 at the north Pacific Geosecs station, *J. Geophys. Res.*, *75*, 7676–7678, 1970.

Craig, H., and J. F. Lupton, Helium-3 and mantle volatiles in the ocean and oceanic crust, in *The Sea*, vol. 7, *The Oceanic Lithosphere*, edited by C. Emiliani, John Wiley, 391–428, 1981.

Craig, H., R. F. Weiss, and W. B. Clarke, Dissolved gases in the equatorial and south Pacific ocean, *J. Geophys. Res.*, *72*, 6165–6181, 1967.

Craig, H., S. Krishnaswami, and B. L. K. Somayajulu, ^{210}Pb-^{226}Ra: radioactive disequilibrium in the deep sea, *Earth Planet. Sci. Lett.*, *17*, 295–305, 1974.

Cranston, R. E., Chromium species in natural waters, Ph.D. dissertation, University of Washington, Seattle, 1979.

Culkin, F., and R. A. Cox, Sodium, potassium, magnesium, calcium and strontium in sea water, *Deep-Sea Res.*, *13*, 789–804, 1966.

Dixon, B. W., J. F. Slowey, and D. W. Hood, Neutron activation analysis of ruthenium in sea water, in The Chemistry and Analysis of Trace Metals in Sea Water, final report, Project 276, Texas A&M Univ., College Station, 1966.

Dittmar, W., Report on the scientific results of the exploring voyage of the H. M. S. Challenger, *Physics and Chemistry*, vol. 1, H. M. Stationery Office, London, 1884.

Elderfield, H., and M. J. Greaves, The rare earth elements in seawater, *Nature*, *296*, 214–219, 1982.

Fabricand, B. P., E. S. Imbimbo, and M. E. Brey, Atomic absorption analyses for Ca, Li, Mg, K, Rb and Sr at two Atlantic stations, *Deep-Sea Res.*, *14*, 785–789, 1967.

Froelich, P. N., and M. O. Andreae, The marine geochemistry of germanium: eksasilicon, *Science*, *213*, 205–207, 1981.

Goldberg, E. D., W. S. Broecker, M. G. Gross, and K. K. Turekian, Marine chemistry, in *Radioactivity in the Marine Environment*, pp. 137–146, U.S. National Academy of Sciences, Washington, D.C. 1971.

Gordon, R. M., J. H. Martin, and G. A. Knauer, Iron in north-east Pacific waters, *Nature*, *299*, 611–612, 1982.

Griel, J. V., and R. J. Robinson, Titanium in sea water, *J. Mar. Res.*, *11*, 173–179, 1952.

Hogdahl, O. T., S. Melsom, and V. T. Bowen, Neutron activation analysis of elements in sea water, in *Trace Inorganics in Water*, *Adv. Chem. Ser.*, vol. 73, pp. 308–325, 1968.

Horibe, Y., K. Endo, and H. Tsubota, Calcium in the South Pacific and its correlation with carbonate alkalinity, *Earth Planet. Sci. Lett.*, *23*, 136–140, 1974.

Hydes, D. J., Aluminum in seawater: control by inorganic processes, *Science*, *205*, 1260–1262, 1979.

Ishibashi, M., Studies on minute elements in sea water, *Rec. Oceanogr. Works Jpn.*, *1*, 88–92, 1953.

Ishibashi, M., T. Shigematsu, Y. Nishikawa, and K. Hirake, Gallium content of seawater, marine organism sediments and other materials related to the ocean, *Nippon Kagaku Zasshi*, *82*, 1141–1143, 1961.

Kaufman, A., The Th^{232} concentration of surface ocean water, *Geochim. Cosmochim. Acta*, *33*, 717–724, 1969.

Knauer, G. A., and J. H. Martin, Seasonal Variations of cadmium, copper, manganese, lead and zinc in water and phytoplankton in Monterey Bay, California, *Limnol. Oceanogr.* *18*, 597–604, 1973.

Knauer, G. A., J. H. Martin, and R. M. Gordon, Cobalt in north-east Pacific Waters, *Nature*, *297*, 49–51, 1982.

Landing, W. M., and K. W. Bruland, Manganese in the North Pacific, *Earth Planet. Sci. Lett.*, *49*, 45–56, 1980.

Matthews, A. D., and J. P. Riley, Occurrence of indium in seawater and some marine sediments, *Nature*, *225*, 1242, 1970.

Mazor, E., G. J. Wasserburg, and H. Craig, Rare gases in Pacific ocean waters, *Deep-Sea Res.*, *11*, 929–932, 1964.

Measures, C. I., and J. D. Burton, The vertical distribution and oxidation states of dissolved selenium in the northeast Atlantic Ocean and their relationship to biological processes, *Earth Planet. Sci. Lett.*, *46*, 385–396, 1980.

Measures, C. I., and J. M. Edmond, Beryllium in the water column of the central North Pacific, *Nature*, *297*, 51–53, 1982.

Millero, F. J., and W. H. Leung, The thermodynamics of seawater at one atmosphere, *Am. J. Sci.*, *276*, 1035–1077, 1976.

Morris, A. W., Dissolved molybdenum and vanadium in the northeast Atlantic Ocean, *Deep-Sea Res.*, *22*, 49–54, 1975.

Morris, A. W., and J. P. Riley, The bromide/chlorinity and sulphate/chlorinity ratio in sea water, *Deep-Sea Res.*, *13*, 699–705, 1966.

Mukherji, P., and D. R. Kester, Mercury distribution in the Gulf Stream, *Science*, *204*, 64–66, 1979.

Noakes, J. E., and D. W. Hood, Boron-boric acid complexes in sea water, *Deep-Sea Res.*, *8*, 121–129, 1961.

Nozaki, Y., K. K. Turekian, and K. L. Von Damm, ^{210}Pb in GEOSECS Water Profiles from the North Pacific, *Earth Planet. Sci. Lett.*, *49*, 393–400, 1980.

Olafsson, J., and J. P. Riley, Some data on the marine geochemistry of rhenium, *Chem. Geol.*, *9*, 227–230, 1972.

Sastry, V. N., T. M. Krishnamoorthy and T. P. Sarma, Microdetermination of zirconium in the marine environment, *Curr. Sci.*, *38*, 279–281, 1969.

Schaule, B. K., and C. C. Patterson, Lead concentrations in the northeast Pacific: evidence for global anthropogenic perturbations, *Earth Planet. Sci. Lett.*, *54*, 97–116, 1981.

Schutz, D. F., and K. K. Turekian, The investigation of the geographical and vertical distribution of several trace elements in water using neutron activation analysis, *Geochim. Cosmochim. Acta.*, *29*, 259–313, 1965*a*.

Schutz, D. F., and K. K. Turekian, The distribution of cobalt, nickel and silver in ocean water profiles around Pacific Antarctica, *J. Geophys. Res.*, *70*, 5519–5528, 1965*b*.

Spencer, P. W., D. E. Robertson, K. K. Turekian, and T. R. Folsom, Trace element calibrations and profiles at the GEOSECS test station in the northeast Pacific Ocean, *J. Geophys. Res.*, *75*, 7688–7696, 1970.

Turekian, K. K., and L. H. Chan, The marine geochemistry of the uranium isotopes, ^{230}Th and ^{231}Pa, in *Activation Analysis in Geochemistry and Cosmochemistry*, edited by A. O. Brunfelt and E. Steinnes, pp. 311–320, Universitets forlaget, Oslo, 1971.

Weiss, R. F., Hydrothermal manganese in the deep sea: scavenging residence time and Mn/^{3}He relationships, *Earth Planet. Sci. Lett.*, *37*, 257–262, 1977.

Wilson, T. R. S., Salinity and the major elements of sea water, in *Chemical Oceanography*, vol. 1, 2nd ed., edited by J. P. Riley and G. Skirrow, pp. 365–413, Academic, New York, 1975.

Wong, G. T. F., and P. G. Brewer, The determination and distribution of iodate in south Atlantic waters, *J. Mar. Res.*, *32*, 25–36, 1974.

TABLE 2. Observed Elemental Concentrations in Sea Water and Predicted Mean Oceanic Concentrations

Atomic Number	Element	Species	Surface Concentration (Sample Depth)	Deep Water Concentration (Sample Depth)	Predicted Mean Water Concentration	Profile Available	References
1	Hydrogen	H_2					
2	Helium		1.7 nmol/kg (2 m)	1.9 nmol/kg (927 m)	1.9 nmol/kg	√	*Clarke et al.* [1970]
3	Lithium		[illegible]	[illegible]	[illegible]	√	[illegible]
4	Beryllium		[illegible]	[illegible]		√	[illegible]
5	Boron	Inorganic Boron	[illegible]	[illegible]	[illegible]	√	[illegible]
6	Carbon	[illegible]	[illegible]	[illegible]	[illegible]	√	[illegible]
7	Nitrogen	N_2	[illegible]	[illegible]	[illegible]	√	[illegible]
		NO_3	[illegible]	[illegible]	[illegible]	√	[illegible]
8	Oxygen	Dissolved O_2	[illegible]	[illegible]	[illegible]	√	[illegible]
9	Fluorine		[illegible]	[illegible]	[illegible]	√	[illegible]
10	Neon		[illegible]	[illegible]	[illegible]	√	[illegible]
11	Sodium		[illegible]		[illegible]	√	[illegible]
12	Magnesium		[illegible]		[illegible]	√	[illegible]
13	Aluminum		[illegible]	[illegible]	[illegible]	√	[illegible]
14	Silicon	Silicate	[illegible]	[illegible]	[illegible]	√	[illegible]
15	Phosphorus	Reactive phosphate	[illegible]	[illegible]	[illegible]	√	[illegible]
16	Sulfur	Sulfate	[illegible]		[illegible]	√	[illegible]
17	Chlorine	Chloride	[illegible]		[illegible]	√	[illegible]
18	Argon		[illegible]	[illegible]	[illegible]	√	[illegible]
19	Potassium		[illegible]	[illegible]	[illegible]	√	[illegible]
20	Calcium		[illegible]	[illegible]	[illegible]	√	[illegible]
21	Scandium		[illegible]		[illegible]	√	[illegible]
22	Titanium		[illegible]			√	[illegible]
23	Vanadium		[illegible]	[illegible]	[illegible]	√	[illegible]
24	Chromium	[illegible]	[illegible]	[illegible]	[illegible]	√	[illegible]
25	Manganese	Dissolved Mn	[illegible]	[illegible]	[illegible]	√	[illegible]
26	Iron		[illegible]	[illegible]	[illegible]	√	[illegible]
27	Cobalt		[illegible]	[illegible]	[illegible]	√	[illegible]
28	Nickel		[illegible]	[illegible]	[illegible]	√	[illegible]
29	Copper		[illegible]	[illegible]	[illegible]	√	[illegible]
30	Zinc		[illegible]	[illegible]	[illegible]	√	[illegible]
31	Gallium		[illegible]		[illegible]	√	[illegible]
32	Germanium		[illegible]	[illegible]	[illegible]	√	[illegible]
33	Arsenic	As(V)	[illegible]	[illegible]	[illegible]	√	[illegible]
		Dimethylarsinate	[illegible]				
		As(III)	[illegible]	[illegible]	[illegible]	√	[illegible]
34	Selenium	Se(VI)	[illegible]	[illegible]	[illegible]	√	[illegible]
		Se(IV)	[illegible]	[illegible]	[illegible]		
35	Bromine	Bromide	[illegible]	[illegible]	[illegible]	√	[illegible]
36	Krypton		[illegible]	[illegible]	[illegible]	√	[illegible]
37	Rubidium		[illegible]	[illegible]	[illegible]	√	[illegible]
38	Strontium		[illegible]	[illegible]	[illegible]	√	[illegible]
39	Yttrium			[illegible]	[illegible]	√	[illegible]
40	Zirconium		[illegible]		[illegible]	√	[illegible]
41	Niobium		[illegible]		[illegible]	√	[illegible]
42	Molybdenum		[illegible]	[illegible]	[illegible]	√	[illegible]
44	Ruthenium		[illegible]		[illegible]	√	[illegible]
45	Rhodium						
46	Palladium						
47	Silver			[illegible]	[illegible]	√	[illegible]
48	Cadmium		[illegible]	[illegible]	[illegible]	√	[illegible]
49	Indium		[illegible]	[illegible]	[illegible]	√	[illegible]
50	Tin		[illegible]		[illegible]	√	[illegible]
51	Antimony		[illegible]	[illegible]	[illegible]	√	[illegible]
52	Tellurium						
53	Iodine		[illegible]	[illegible]	[illegible]	√	[illegible]
54	Xenon		[illegible]	[illegible]	[illegible]	√	[illegible]
55	Cesium		[illegible]	[illegible]	[illegible]	√	[illegible]
56	Barium		[illegible]	[illegible]	[illegible]	√	[illegible]
57	Lanthanum		[illegible]	[illegible]	[illegible]	√	[illegible]
58	Cerium		[illegible]	[illegible]	[illegible]	√	[illegible]
59	Praseodymium						
60	Neodymium		[illegible]	[illegible]	[illegible]	√	[illegible]
61	Promethium						
62	Samarium		[illegible]	[illegible]	[illegible]	√	[illegible]
63	Europium		[illegible]	[illegible]	[illegible]	√	[illegible]
64	Gadolinium		[illegible]	[illegible]	[illegible]	√	[illegible]
65	Terbium						
66	Dysprosium		[illegible]	[illegible]	[illegible]	√	[illegible]
67	Holmium						
68	Erbium		[illegible]	[illegible]	[illegible]	√	[illegible]
69	Thulium						
70	Ytterbium		[illegible]	[illegible]	[illegible]	√	[illegible]
71	Lutetium						
72	Hafnium		<8 ng/kg		[illegible]		[illegible]
73	Tantalum		<2.5 ng/kg		<2.5 ng/kg		[illegible]
74	Tungsten		[illegible]		[illegible]		[illegible]
75	Rhenium		[illegible]	[illegible]	[illegible]		[illegible]
76	Osmium						
77	Iridium						
78	Platinum						
79	Gold		[illegible]		[illegible]		[illegible]
80	Mercury		[illegible]	[illegible]	[illegible]		[illegible]
81	Thallium		[illegible]		[illegible]		[illegible]
82	Lead		[illegible]	[illegible]	[illegible]	√	[illegible]
83	Bismuth		[illegible]		[illegible]		[illegible]
84	Polonium						
86	Radon						
88	Radium						
89	Actinium						
90	Thorium		[illegible]		[illegible]		[illegible]
91	Protactinium						
92	Uranium		[illegible]		[illegible]	√	*Turekian and Chan* [1971]

Deep water concentration data are for comparison only. Where possible they are from the Pacific Ocean, which usually shows the greatest concentration difference; otherwise they are from the Atlantic. [illegible] normalized to 35 ‰.
*Atlantic Ocean deep water data.

M. S. Quinby-Hunt is with the Marine Sciences Group, Department of Paleontology, University of California, Berkeley, CA 94720. K. K. Turekian is with the Department of Geology and Geophysics, Yale University, Box 6666, New Haven, CT 06511.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For full articles and meeting reports send one copy of the double-spaced manuscript to *Eos* c/o AGU at the address below and three copies to one of the editors, or send all four copies to *Eos*. For news items, send two copies of the double-spaced manuscript to *Eos*.

Editor-in-Chief: A. F. Spilhaus, Jr.; **Editors:** Marcel Ackerman, Mary P. Anderson, Peter M. Bell (News), Kevin C. Burke, Bruce Doe, Robert H. Eather (History), Clyde C. Goad, Arnold L. Gordon, Louis J. Lanzerotti; **Editorial Staff:** Gregg Forte—*Managing Editor*; Kathleen M. Lafferty—*Editorial Assistant*; Barbara T. Richman—*News Writer*; Mario E. Godinez—*News Intern*; **Production Staff:** James Hebblethwaite, Dae Sung Kim, Lisa Lichtenstein, Vivian Nelson.

Officers of the Union
James A. Van Allen, President; Charles L. Drake, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

For advertising information, contact Robin E. Little, advertising coordinator, 202-462-6903.

Subscription price to members is included in annual dues ($20.00 per year). Information on institutional subscriptions is available on request. Second-class postage paid at Washington, D. C., and at additional mailing offices. *Eos, Transactions, American Geophysical Union* (ISSN 0096–3941) is published weekly by

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D. C. 20009

Cover. An equal-area map of the world with edges formed by major tectonic plate boundaries. This tectonic plate map prepared by Athelstan Spilhaus allows comparison of plate areas and also preserves plate shapes. It is constructed from four aspects of a transverse Mollweide projection joining at the north pole. The four aspects have centers at the equator at 60°W, 160°W, 120°E, and 20°E.

News & Announcements

Bird Demise Tied to El Niño

The first massive disappearance of a total bird population from a tropical atoll has been credited to the 1982 El Niño.

Roughly 17 million seabirds—virtually the entire adult bird population on Christmas Island in the mid Pacific—either perished or fled, leaving behind thousands of nestlings to starve, according to a report from the National Science Foundation. Among those birds that either abandoned the world's largest coral atoll or died are 14 million sooty terns, at least 1.5 million wedge-tailed shearwaters, and 1 million birds comprising 16 other species.

Ralph W. Schreiber, curator of ornithology at the Natural History Museum of Los Angeles County in California, said he believes that the El Niño may have disrupted the ecological food chain by cutting off nutrients upwelling from the ocean depths. These nutrients sustain the fish and squid that are the birds' only food supply. When the flow of ocean nutrients shifted, the fish and squid sought an area richer in nutrients, leaving the Christmas Island birds to their plight. Schreiber has studied birds and mammals in the central Pacific Ocean for more than 15 years.

El Niños, recurring on an average of every 7 years, are anomalies in the interaction of the atmosphere and the oceans and include a warming of the upper ocean and a weakening of the trade winds. This ocean warming may be a response to a relaxation of the winds in the western or central Pacific Ocean, although other hypotheses have been advanced. In addition to previously documented and devastating effects of the El Niño on the marine food chain, the anomaly has been tied to warmer than normal winters in eastern North America.

'What has happened [on Christmas Island] was a real shock and a catastrophe when put in the context of the breeding biology of these species,' Schreiber said. He learned in November of the birds' disappearance and demise when he visited the atoll; he is uncertain of the exact departure date of the birds.

Schreiber hopes to discern when, or if, the birds will return to the island, what reproductive cycles they will reestablish, and what their diet and reproductive success will be during recovery.

Christmas Island, just north of the equator, was discovered on Christmas Eve in 1777 by the English navigator Captain James Cook. It is now part of the Republic of Kiribati.

Oceanography (cont. on p. 132)

Oceanography *(cont. from p. 131)*

Pacific Warm Event

A preliminary description of the 1982 equatorial warm event was published in February as a special issue of the *Tropical Ocean-Atmosphere Newsletter*. A followup special issue is planned to discuss the equatorial Pacific environment during the first 6 months of 1983.

The newsletter is published bimonthly by the University of Washington's Joint Institute for the Study of the Atmosphere and Ocean (JISAO), with support from the Equatorial Pacific Ocean Climate Studies (EPOCS) program within the National Oceanic and Atmospheric Administration. For additional information, contact David Halpern, JISAO, University of Washington, AK-40, Seattle, WA 98195.

Opinion

Bottom Water

I read with great interest your writeup on the 'Mysteries of Bottom Water' in the March issue of The Oceanography Report (*Eos*, March 1, 1983, p. 85).

I can recall the time, not so very long ago, when some very prominent physical oceanographers dismissed the notion advanced by paleo-oceanographers that the deep ocean environment is far from steady. It is nice to see them come around, some of them even to start to pay attention to what paleo-oceanographers have to say.

Detmar Schnitker
Woods Hole Oceanographic Institution
Woods Hole, Mass.

Classified

RATES PER LINE

Positions Wanted: first insertion $1.75, additional insertions $1.50.

Positions Available, Services, Supplies, Courses, and Announcements: first insertion $3.50, additional insertions $2.75.

Student Opportunities: first insertion free, additional insertions $1.50.

There are no discounts or commissions on classified ads. Any type style that is not publisher's choice is charged for at general advertising rates. *Eos* is published weekly on Tuesday. Ads must be received in writing on Monday, 1 week prior to the date of publication.

Replies to ads with box numbers should be addressed to Box —, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D. C. 20009.

For further information, call toll free 800-424-2488 or, in the Washington, D. C., area, 462-6903.

POSITIONS AVAILABLE

Imperial College, Geology Department, London SW7 2BP, England. RESEARCH ASSISTANT sought immediately for a possible post in experimental fracture mechanics of rocks, to last for up to one year beginning in the next few months.

Post-graduates (MSc) or post-doctoral candidates with limited experience are sought, but an interest in fracture at all scales in the earth plus some experience of experimental fracture mechanics is essential. Preference given to candidates interested in earthquakes.

Salary up to £8383 according to qualifications etc.

Write in the first instance to Dr. Barry Atkinson at the above address, enclosing c.v. and at least two written references.

Earth and Planetary Aeronomy/University of Arizona. A postdoctoral position in atmospheric research is announced, subject to the availability of funds. Areas of interest include the atmospheres of Venus, Earth, Jupiter, and Titan. A background in planetary or atmospheric science is desirable, but those with experience in related areas will also be considered. Address inquiries to Professor D.M. Hunten, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

The University of Arizona is an equal opportunity employer.

President/University Corporation for Atmospheric Research (UCAR), Boulder, Colorado. The Search Committee of the UCAR Board of Trustees invites nominations and applications for the President and Chief Executive Officer of UCAR. The Board of Trustees expects to fill the position promptly and seeks to have the individual in office on July 1 or as soon after 1 July 1983 as possible.

UCAR is a private, nonprofit consortium of 48 U.S. and two Canadian institutions with doctoral programs in the atmospheric sciences and related fields. UCAR's major activities consist of overseeing the programs of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and the National Scientific Balloon Facility (NSBF) in Palestine, Texas, and managing their operations; the planning and conduct of special, cooperative atmospheric research programs; and fostering atmospheric research in the national interest.

To be considered for the UCAR presidency, a person should have demonstrated imaginative scientific and management leadership ability of high quality and specific knowledge of the atmospheric and related sciences. A complete description of the duties and responsibilities of the President and qualifications for the candidates may be obtained by writing to Dr. Donahue (address below). Applications and nominations, which should be postmarked no later than 6 May 1983, should be addressed to:

Dr. Thomas M. Donahue
Chairman, Search Committee
UCAR
P.O. Box 3000
Boulder, Colorado 80307

UCAR is an equal opportunity, affirmative action employer.

Chairman/Division of Marine Geology and Geophysics. The Rosenstiel School of Marine and Atmospheric Science is searching for a Chairman of its Division of Marine Geology and Geophysics. The Division at present consists of 11 faculty and about 50 graduate students. Applicants should be recognized scientists in geology or geophysics and have experience in leading cooperative research. Applications, including a current professional resume and names of three references should be sent by 1 May 1983 to: Dr. Friedrich Schott, Chairman Search Committee, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149.

Position will remain open until filled.

The University of Miami is an equal opportunity/affirmative action employer.

Assistant Research Scientist or Assistant Professor

Scripps Institution of Oceanography University of California, SD

Scripps Institution of Oceanography has an opening for an assistant research scientist or assistant professor to participate in ocean related programs using acoustic, magnetic, optical and other physical techniques.

Candidates should have a Ph.D. in physics, geophysics and engineering and should have interest in formulating and taking part in seagoing research and have publication record. Salary range: $22,900–$26,800.

Appointment duration two years starting summer of 1983 with possibility of indefinite extension. Appointment to assistant professor would require teaching experience.

Send vitae and names of references to:

K. M. Watson, Director

or

F. N. Spiess, Deep Tow Group Leader, Marine Physical Laboratory University of California, San Diego, CA 92152.

Closing date: 20 May 1983.

The University of California, San Diego is an equal opportunity/affirmative action employer.

GKSS—FORSCHUNGSZENTRUM GEESTHACHT GMBH and UNIVERSITÄT HAMBURG

are jointly seeking a recognized Meteorologist, Oceanographer, Hydrologist or Hydrodynamicist to serve as

INSTITUTSLEITER (C 4) at GKSS and as PROFESSOR at the University

GKSS is a non-profit research center with more than 600 employees. It is situated outside Hamburg on the Elbe River in a large wooded estate. GKSS has joined with the Institutes of Meteorology and Oceanography at the University of Hamburg and with the Max-Planck-Institute for Meteorology to form a united research effort in the areas of:

ENVIRONMENT and CLIMATE

with projects relating to:

- Pollution of estuaries and rivers and associated transport phenomena
- Water levels, currents, and waves in the North Sea and in the North Atlantic
- Transport of dissolved and suspended matter in coastal waters
- Diffusion processes in the atmosphere
- Climatological changes, both natural and anthropogenic
- Development and application of remote sensing techniques.

The incumbent shall be a director of the Institute of Physics at GKSS and an active member of the geosciences faculty of the University of Hamburg, and he shall have a significant influence in shaping the united research effort. He should be capable of bringing fundamental research to bear on practical problems. Experience with the development and application of numerical models and their verification using field experiments is essential, as is willingness to do applied research under contract.

Applications should be submitted not later than May 15, 1983 to:

GKSS—FORSCHUNGSZENTRUM GEESTHACHT GMBH
Max-Planck-Straße
D-2054 Geesthacht
Federal Republic of Germany

Geesthacht, March 11, 1983.

Sedimentary Geology/University of Pittsburgh. The Department of Geology and Planetary Science invites applications for a tenure-stream faculty position in sedimentary geology at the assistant professor level, which is expected to be open beginning September 1983. We seek candidates with expertise in one or more of the following fields: sedimentary petrology, sedimentation, stratigraphy, sedimentary geochemistry, and economic geology of non-metallic deposits. The position involves development of a vigorous research program, supervision of graduate student research, and teaching of undergraduate and graduate courses.

Applicants should submit a letter of application, a statement of research interests, transcripts, vita, and arrange to have five letters of recommendation sent to:

Dr. E. G. Lidiak, Chairman, Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260.

An Equal Opportunity Employer.

Chairman—Department of Geological Sciences, Wright State University. The Department of Geological Sciences invites applications for the position of chairman, to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435.

Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Postdoctoral Position in Solar-Terrestrial Physics. The Center for Atmospheric and Space Sciences of Utah State University has a postdoctoral position in solar-terrestrial physics. The position is for one year but has renewable opportunities. The recipient is expected to develop theoretical models to describe the large-scale flow of plasma in the terrestrial ionosphere and magnetosphere and to study the stability of the flow. Candidates should have a Ph.D. and a background in space physics and/or plasma physics. Send letter of application, resume, and the names and addresses of two references by April 30 to Professor R. W. Schunk, Center for Atmospheric and Space Sciences, Utah State University, Logan, Utah 84322 (801-750-2974).

Utah State University is an Affirmative Action/Equal Opportunity employer.

Oregon State University/Faculty Position. The Department of Geology invites applications for a tenure-track position in geophysics at rank of assistant professor beginning fall, 1983. The position is supported at 50% level by the department to teach two courses, introductory and exploration geophysics. The successful applicant would need to provide up to 50% salary support from research grants or other sources. Ability to maintain an active, externally-funded research program involving students and ability as a classroom teacher of geology students are important considerations. Send resume, transcripts, and statement of teaching and research interests to Robert S. Yeats, Chairman, Dept. of Geology, OSU, Corvallis, OR 97331-5506. List at least 3 references to whom the committee may write. Application deadline May 15, 1983. OSU is an Affirmative Action/Equal Opportunity Employer and complies with Section 504 of the Rehabilitation Act of 1973.

Research Position/Space Physics. The Space Physics and Astronomy Department at Rice University seeks applicants for one or more full-time research positions within the department. Successful applicant(s) will play key role(s) in the development of theoretical three-dimensional models of the Earth's electromagnetic field. Applicants should have knowledge of, and interest in, at least one of the following areas: solar-wind magnetosphere interactions, magnetosphere-ionosphere coupling, ionosphere-atmosphere coupling, atmospheric electricity. Experience and/or interest in numerical modeling is an important consideration.

Title and salary level commensurate with experience, ranging from one-year Research Associateship (renewable in subsequent years depending on performance) to open-ended Research Scientist appointment in the Center for Space Physics. Please send resume and names of three professional references to T. W. Hill or R. A. Wolf, Space Physics and Astronomy Department, Rice University, Houston, TX 77251.

The University is an equal opportunity/affirmative action employer.

Atmospheric Sciences: Research Assistant, Oregon State University. Applications are invited for a position as Research Assistant which is expected to be available in the Climatic Research Institute, Oregon State University, beginning in May 1983. This position involves assistance in the production and analysis of computer simulations with large numerical models of the atmosphere and ocean, and requires a basic familiarity with atmospheric modeling, data analysis techniques, and programming. Salary within the range $18,000—$22,000 will depend upon qualifications and experience. Interested candidates possessing a M.S. degree in atmospheric or computer science are invited to submit an application with a summary of their experience and the names of two professional references to Dr. W. L. Gates, Director, Climatic Research Institute, Oregon State University, Corvallis, Oregon 97331 before 2 May 1983.

Oregon State University is an Affirmative Action/Equal Opportunity Employer and complies with Section 504 of the Rehabilitation Act of 1973.

Research Positions for Mathematical Physicists. Applications are invited for several research positions at the Center for Studies of Nonlinear Dynamics, La Jolla Institute, beginning summer 1983. Current research involves work on nonlinear wave-wave interactions, acoustic, optical, and radio wave propagation in random media, and fluctuation phenomena in the statistical mechanics of chemical and geophysical systems. Physicists and applied mathematicians who are interested in working on problems of the above type should send resumes and arrange for three letters of recommendation to be sent to Dr. Stanley Flatte, Director, CSND, La Jolla Institute, 8950 Villa La Jolla Drive, Suite 2150, La Jolla, California 92037.

La Jolla Institute is an equal opportunity/affirmative action employer.

Atmospheric Chemist/University of Michigan. The Department of Atmospheric and Oceanic Science invites applications for a tenure track position in Atmospheric Chemistry to begin January 1984. Successful applicant must have a demonstrated commitment to excellence in teaching and experimental research. A joint appointment with the Department of Chemistry has been a tradition of this position and is expected to continue. Responsibilities will include teaching atmospheric chemistry at the undergraduate and graduate level, development of relevant curriculum, and directing a high quality independent experimental research program. Faculty rank and salary commensurate with qualifications. Send resume, statement of research interests and the names of four references before July 1, 1983 to: G. R. Carignan, Director, Space Physics Research Laboratory, Department of Atmospheric and Oceanic Science, University of Michigan, 2455 Hayward, Ann Arbor, MI 48109.

The University of Michigan is an Equal Opportunity/Affirmative Action Employer.

Postdoctoral Position in Physical Oceanography. A postdoctoral appointment in physical oceanography will be available beginning September, 1983 in the College of Marine Studies, University of Delaware, Newark, Delaware. The initial appointment will be for one year with probable extension for a second year. The salary will be $20,000-$24,000 per year, depending on experience. Funds for the position will be available largely from a grant by NSF for conduct and analysis of a field observational study of the shelfbreak front in the Middle Atlantic Bight.

The person obtaining the appointment would be responsible for a portion of the planning and execution of the field study, much of the subsequent data analysis and interpretation, and teaching of one graduate level course in physical oceanography each year. The successful applicant must have received the Ph.D. in physical oceanography or a closely related field by the starting date of his appointment. Preference will be given to applicants with direct experience in field observations.

To apply send a complete resume and the names of three references to Professor R. W. Garvine, College of Marine Studies, University of Delaware, Newark, DE 19711. (Telephone: (302) 738-2169).

The University of Delaware is an equal opportunity/affirmative action employer.

Save for Spring

Join Now to be Eligible for the Member Registration Fee at the Spring Meeting

- Pay dues now and register as an AGU member—nonmember registration fees include the equivalent of one year's dues.
- Receive the abstract issues of *Eos* in advance of the meeting if payment is received by April 30—and *Eos* weekly for the rest of the year.
- Be recognized as an AGU member at the meeting—AGU members have special badges.

Send your check with the application below or charge it to your credit card.

MEMBERSHIP APPLICATION 1983
Complete both sides

AMERICAN GEOPHYSICAL UNION
2000 FLORIDA AVENUE
WASHINGTON, DC 20009

REGULAR MEMBERS—Individuals who are professionally engaged in or associated with geophysics including college or university students. Students enrolled in at least a half-time program of study leading to a degree receive special reduced dues and journal subscription rates. ASSOCIATES—individuals not professionally involved but with an interest in geophysics. Associates may not vote or hold office.

Send applications together with payment for first year's dues and journals to AGU.

PREFERRED MAILING ADDRESS

Each line of boxes represents one line of address. Please abbreviate as necessary to fit within space provided. PLEASE PRINT ALL INFORMATION CLEARLY.

FORE NAMES AND/OR INITIALS ______ LAST NAME ______

FIRST LINE OF ADDRESS ______

ID NUMBER - OFFICE USE

SECOND LINE OF ADDRESS (OPTIONAL) ______

CITY ______ STATE (USA only) ______ ZIP CODE (USA only) ______

COUNTRY ______ FOREIGN POSTAL CODE ______

TELEPHONE (Phone numbers provided will be published in the membership directory.)

HOME ______ AREA CODE ______ NUMBER ______

OFFICE ______ AREA CODE ______ NUMBER ______ EXT. ______

TITLE ☐ DR ☐ PROF ☐ MR ☐ MS OTHER – SPECIFY ______

EMPLOYMENT

EMPLOYER ______

JOB TITLE ______

DEPARTMENT ______

LOCATION ______ CITY ______ STATE (USA only) ______ ZIP CODE (USA only) ______

COUNTRY ______ FOREIGN POSTAL CODE ______

JOB FUNCTIONS

Check up to 3 which best describe your area(s) of functional responsibility.

A ☐ CONSULTANT
B ☐ STUDENT
C ☐ TEACHING
D ☐ BASIC RESEARCH
E ☐ APPLIED RESEARCH
F ☐ ENGINEERING
G ☐ ADMINISTRATIVE-R&D
H ☐ ADMINISTRATIVE-NON R&D
I ☐ FIELD EXPLORATION
J ☐ RETIRED
M ☐ OTHER - please specify ______

EMPLOYER CLASSIFICATION

Check the one which best identifies your employer.

A ☐ MILITARY ACTIVE
B ☐ U.S. FEDERAL GOV'T
C ☐ OTHER GOVERNMENT
D ☐ UNIVERSITY
E ☐ OTHER NON-PROFIT
F ☐ BUSINESS OR INDUSTRY
G ☐ SELF EMPLOYED
H ☐ UNEMPLOYED
I ☐ OTHER - please specify ______

GENERAL

DATE OF BIRTH ______ MONTH/YEAR

EDUCATION — Indicate level of highest degree earned.

☐ DOCTORATE
☐ MASTERS
☐ BACHELORS
☐ NO COLLEGE DEGREE

INSTITUTION AT WHICH HIGHEST DEGREE EARNED ______

MAJOR ______

YEAR HIGHEST DEGREE EARNED ______

SECTION AFFILIATION

Check the sections with which you desire affiliation and indicate the single section with which you wish to be principally affiliated.

☐ GEODESY (G)
☐ SEISMOLOGY (S)
☐ ATMOSPHERIC SCIENCES (M)
☐ GEOMAGNETISM AND PALEOMAGNETISM (GP)
☐ OCEANOGRAPHY (O)
☐ VOLCANOLOGY, GEOCHEMISTRY, & PETROLOGY (V)
☐ HYDROLOGY (H)
☐ TECTONOPHYSICS (T)
☐ PLANETOLOGY (P)

SOLAR-PLANETARY RELATIONSHIPS

☐ AERONOMY (SA)
☐ COSMIC RAYS (SC)
☐ MAGNETOSPHERIC PHYSICS (SM)
☐ SOLAR & INTERPLANETARY PHYSICS (SS)

MAJOR SECTION AFFILIATION ______

Turn page for reverse of application.

cut along line

Hydrogeologist. Applications are invited for a hydrogeologist—engineering geologist position starting in January 1984. Rank and salary are dependent on qualifications and experience. Ph.D. degree and registration as a professional engineer desirable.

Responsibilities will include undergraduate and graduate teaching and graduate research in hydrogeology and engineering geology. Applicants should have experience in field groundwater investigations of regional site specific nature/groundwater resource analyses/waste disposal/groundwater contamination studies. Experience in applying remote sensing to hydrogeology and engineering studies would be helpful.

Send resume and names of three references to J. J. Finney, Head, Geology Department; Colorado School of Mines, Golden, Colorado 80401. Applications will be accepted until September 15, 1983. The Colorado School of Mines is an affirmative action/equal opportunity employer.

Assistant Research Oceanographer Position. The Center for Coastal Studies, Scripps Institution of Oceanography, has an opening for a physical oceanographer with a general background in nearshore processes with emphasis on field and remote sensing investigations of surface gravity waves.

Incumbent will be expected to conduct field and remote sensing experiments of wave properties, dynamics and climatology in the nearshore environment. Responsibilities will also include design and implementation of surface gravity wave measurements supporting a variety of other nearshore processes investigations.

Minimum qualifications for this position are the Ph.D. degree in oceanography and a demonstrated publication record. Successful candidate should have previous field experience as well as demonstrated expertise in wave propagation theory, array design and data adaptive directional spectrum estimation theory. High levels of skill in oral and written communication are necessary.

Appointment in the University of California system is for 1 or 2 years (renewable) and will be at the Assistant Research I, II, or III level, salary from \$22,900-\$25,200, commensurate with qualifications. Submit resume, indicating an interest in this specific position together with a minimum of three references, before 4 May 1983, to:

D. L. Inman, Director, Center for Coastal Studies
A-009, Scripps Institution of Oceanography
University of California-San Diego
La Jolla, CA 92093.

SIO/UCSD is an Equal Opportunity/Affirmative Action Employer.

Faculty Position/Physical Oceanography, University of Maryland Center for Environmental and Estuarine Studies (UMCEES). The Horn Point Environmental Laboratories of UMCEES invite applications for a tenure-track (rank open) position for a physical oceanographer. The physical oceanographic program is young and developing, so that candidates with a wide range of research interests will be considered. Opportunities exist for oceanographers with experimental, theoretical, or numerical modeling skills. In addition, the strong chemical and biological programs provide opportunities for interdisciplinary research. Although some preference will be given to applicants with interests in continental shelf and estuarine circulation processes, the primary criterion for selection of the successful candidate is the ability to develop a strong research program. The closing date for applications is May 16, 1983. Applications and a list of references should be sent to:

Dr. William C. Boicourt
Chairman, Search Committee
University of Maryland
Center for Environmental and
Estuarine Studies
Horn Point Environmental Laboratories
P. O. Box 775
Cambridge, Maryland 21613.

The University of Maryland is an Affirmative Action/Equal Opportunity Employer.

Statistician (Scientist II)/National Center for Atmospheric Research. To work as a scientist/statistician in a multidisciplinary group conducting studies of environmental societal impact of atmospheric processes and carry out independent research program in statistical meteorology and related areas. Requirements include Ph.D. in statistics or mathematics or equivalent skill in applying quantitative techniques such as multiple regression analysis, time series modeling and decision analysis to problems in the atmospheric sciences, demonstrated publications record, and commitment to work in multidisciplinary research projects. Skill in computer programming (FORTRAN) and familiarity with statistical computing techniques as well as statistical software packages desired. A scientist II position is for a non-renewable term of up to four years. Individual may then be appointed to scientist III in accordance with UCAR policy. Position will be available on or about October 1983. To apply contact: Margareta Domecki, 303-494-5151 or send resume and list of publications to: NCAR, Employment, P. O. Box 3000, Boulder, Colorado 80307.

An equal opportunity/affirmative action employer.

Staff Scientists/Systems Analysts. Research and Data Systems, Inc. has openings available for Staff Scientists, Systems Analysts and Programmer/Analysts to work in areas involved in the processing and application of data from satellite based remote sensing systems. Particular needs involve the analysis and processing of Earth Radiation Budget, Microwave, AVHRR and LANDSAT data. Needs also exist in the areas of interactive image graphics, software engineering, realtime processing and satellite data communications. Successful candidates will have an advanced degree in meteorology, physics, engineering, mathematics, or computer science. Hardware background should include IBM, DEC, CYBER or HP-1000 equipment. Send resume in confidence to:

Research and Data Systems, Inc.
10300 Greenbelt Road, Suite 206
Lanham, Maryland 20706
Telephone: (301) 390-6100.

Igneous or Metamorphic Petrology. The Department of Geology seeks to fill a tenure track position in petrology beginning either August 15, 1983 or January 1, 1984. Appointment will be at the rank of assistant professor. Post-doctoral experience is considered important. The successful candidate will be expected to develop an aggressive research program, teach both graduate (Ph.D., MS) and undergraduate levels and interact with an active group of faculty and students in mineralogy, petrology and geochemistry. Research facilities in the department include: automated electron microprobe, solid-source mass spectrometer, gas-source mass spectrometer, SEM, AA, non-automated XRF, and Harris 300 computer. Please send a resume, a statement of research interests and the names of at least three references to: Chairman, Petrology Search Committee, Department of Geology, Northern Illinois University, Dekalb, Illinois 60115.

Application deadline is May 1, 1983, although search will continue until position is filled.

Northern Illinois University is an equal opportunity/affirmative action employer.

Earthquake Engineering/Geosciences. The Lawrence Livermore National Laboratory, located in the San Francisco Bay area, has a permanent opening at the MS or Ph.D. level in engineering geosciences. Emphasis of present projects in the field of earthquake risk analysis and requires knowledge of earth sciences, geotechniques, probabilities, and computer programming. Because of the rather large spectrum of projects undertaken in the Geosciences Group, the preferred candidate will have a broad background in engineering.

Salary is commensurate with degree and experience. Please send resume to: D. L. Betzmenter, LAWRENCE LIVERMORE NATIONAL LABORATORY, P.O. Box 808, L-95, KES-013, Livermore, CA 94550, and or call 415-422-0305, 422-0268 or 423-0196. U.S. citizenship is required.
LLNL is an equal opportunity employer M/F/H/V.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Calderas and Hydrothermal Systems. Held in Yellowstone National Park, August 22–27, 1983. College credit available. For more information, contact: THE YELLOWSTONE INSTITUTE, Box 515, Yellowstone National Park, WY 82190. (406) 443-0861.

AGU membership application continued from preceding page

CATEGORY – Check category for which you are applying.

(M) ☐ MEMBER
Individuals professionally engaged in or associated with geophysics and college or university students in at least half-time program of study leading to a degree. May vote and hold office.

(A) ☐ ASSOCIATE (Annual dues \$20)
Individuals not professionally involved but with an interest in geophysics. May not vote or hold office.

Membership is on a calendar year basis.
Membership applications received after October 1 will be made effective as of January 1 of the following year, unless otherwise requested.

DUES RATE (MEMBERS ONLY)
☐ REGULAR MEMBERSHIP Annual dues \$20.
(ST) ☐ STUDENT MEMBERSHIP Annual dues \$7. College or university student in at least half-time program of study leading to a degree.
(IS) ☐ INDIVIDUAL SUPPORTING MEMBERSHIP Dues plus annual contribution \$80 or more.
(SP) ☐ SPOUSE MEMBERSHIP Annual dues \$5. Does not include *Eos* subscription. Provide membership number of spouse
(L) ☐ LIFE MEMBERSHIP. A single payment (currently \$300) is acceptable in lieu of annual dues. Privileges accorded are those granted to all members and have been changed from time to time.

PUBLICATIONS

MEMBER JOURNAL SUBSCRIPTION RATES – 1983

As an AGU member or associate, you will receive *Eos* each week. You may subscribe to additional publications at very low member rates; simply check those desired. Subscriptions are on a calendar year basis. New members will receive back issues of these journals to the beginning of the year. Remember to add payment to your member dues. Members outside the U.S. must add to the subscription rate the foreign postage surcharge. Additional charge for airmail of printed edition quoted on request. Service does not begin until payment is received. In accepting journals at these rates you are agreeing that the issues will not be used in libraries or reading rooms for at least two years.

Member or Associate	Student	*Foreign Postage Surcharge	Microfiche Edition (Airmail)	Printed Edition	(Select either microfiche or printed edition)
					Eos (\$14 of dues is allocated).
					Journal of Geophysical Research is published in three monthly sections:
\$42	\$19	\$18	☐	☐	Space Physics, Section A (blue) Bengt Sonnerup, Editor, 2900 pages anticipated for 1983.
\$48	\$26	\$21	☐	☐	Solid Earth and Planets, Section B (red) Gerald Schubert, Editor, 5600 pages anticipated for 1983.
\$38	\$21	\$18	☐	☐	Oceans and Atmospheres, Section C (green) Ralph Cicerone, Editor, Atmospheric Chemistry and Aeronomy; A.D. Kirwan, Jr., Editor, Oceanography and Boundary Layer Meteorology. Members may subscribe to the full section or to either half of JGR Green published in alternate months for half the subscription price. 3200 pages anticipated for 1983.
\$19	\$11	\$9	☐	☐	Atmospheric (only)
\$19	\$11	\$9	☐	☐	Oceanography (only)
\$40	\$20	\$8	☐	☐	Water Resources Research Published six times a year. Recognized as the leading journal in the water sciences (containing both natural and social sciences). Jared Cohon and Stephen J. Burges, Coeditors, 1200 pages anticipated for 1983.
\$45	\$23	\$10	☐	☐	Reviews of Geophysics and Space Physics An important addition to each geophysicist's permanent library; Andrew Nagy, Editor, 2300 pages anticipated for 1983.
\$22	\$20	\$5	☐	☐	Geophysical Research Letters Reaches more members than any other AGU publication except EOS; monthly reports of fast moving areas of research. Douglas G. Torr and R. E. Stecker, Coeditors, 1200 pages anticipated for 1983.
\$33	\$27	\$8	☐	☐	Radio Science Published six times a year. Alex Ishimaru, Editor, 1100 pages anticipated for 1983.
\$22	\$11	\$4	☐	☐	Tectonics Published bi-monthly. The newest addition to AGU's family of prestigious journals, Tectonics is devoted to publishing leading papers in the structure and evolution of the terrestrial lithosphere, integrative tectonics, structural geology, and materials science. Editor, John F. Dewey. 600 pages anticipated for 1983.

*Non-U.S. include with payment.

PAYMENT

☐ Payment enclosed Charge to ☐ VISA ☐ AMERICAN EXPRESS ☐ MASTERCARD (INTERBANK) No. ____

Total Due \$ ____

Signature ____

Date ____ Card No. ____

Expiration date ____

SPONSORSHIP

Associates do not need a sponsor. If you are applying for membership at the reduced student dues rate, your sponsor must be a faculty member.

Signature of Sponsor ____ ☐ AGU Member ☐ Non Member

Name ____ (Please Print) ____ Address ____

FOR AGU OFFICE USE ONLY

SOURCE 83.1.9 CREDIT ____ CHECK NO. ____ BACKUP CODE ____

cut along line

AGU

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation; the letter A denotes the Atmospheric Sciences section, which was formerly the Meteorology section.

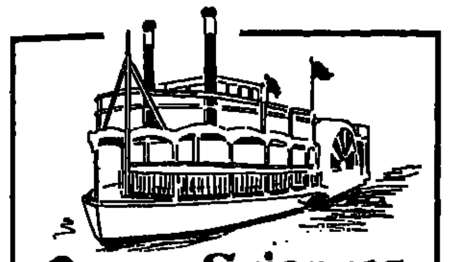
Regular Member

Robert B. Batchelder (O), François Brunel (SM), J. Charles Klose (O), Audrey L. S. Roe (GP), Keith Stowe (O), S. A. Thorpe (O), James C. Ulwick (SA), Hiroshi Watanabe (V), Yukio Watanabe (SM).

Student Member

Frederick Chester (T), Richard P. Hooper, Lynn A. McMurdie (M), Avis D. Newell (O), Arnfinn Prugger (S), David M. Sherman (V), Roy A. Swanson (P), Robin George Williams (O), Ross W. Williams (V).

Meetings



Ocean Sciences Meeting

Abstract Deadline: October 19, 1983

New Orleans, Louisiana Jan. 23–27, 1984

Call for Papers

Abstracts must be received at AGU by October 19, 1983. Late abstracts (1) may be summarily rejected by program chairman or (2) if accepted, will be charged a \$25 late fee in addition to the regular publication charge and may not be published in advance of the meeting.

The 1984 Ocean Sciences Meeting of the American Geophysical Union (AGU) will be held January 23–27, 1984, in New Orleans. Housing and registration information will be published in *Eos* and mailed to anyone requesting information on the meeting. Cosponsoring societies are the American Society of Limnology and Oceanography (ASLO); the Acoustical Society of America (ASA); the American Meteorological Society (AMS); the Marine Technology Society (MTS); and the Institute of Electrical and Electronics Engineers Oceanic Engineering Society (OES).

General Regulations

Abstracts may be rejected without consideration of their content if they are not received by the deadline or are not in the proper format. Abstracts may also be rejected if they contain material outside the scope of the meeting or if they contain material already published or presented elsewhere. **Only one contributed paper by the same first author will be considered** for presentation; additional papers (unless invited) will be automatically rejected.

Abstracts not authored by a member of AGU or of one of the cosponsoring societies must be sponsored by such a member; this includes invited abstracts.

There is a publication charge of \$40 (\$30 if prepaid) for each abstract. The publication charge is only \$20 (\$15 if prepaid) if the first author is a student. Both invited and contributed papers are subject to the publication charge. Prepayment of the publication charge saves money. Send a check for \$30 (\$15 for students) with your abstract. Abstracts must be received at AGU by October 19 to avoid an additional \$25 charge.

AGU will acknowledge receipt of all abstracts. Notification of acceptance and scheduling information will be mailed to corresponding authors in early December.

Abstracts

The abstract page is divided into two parts: the abstract itself and the submittal information. Please follow carefully the instructions for each part. Use a carbon ribbon to type the material, and do not exceed the maximum dimensions (11.8 cm by 18 cm) of the abstract. Abstracts that exceed the noted size limitation will be trimmed to conform without regard to content.

The meeting program will be prepared by photographing the abstracts exactly as they are received. Use the model abstract to prepare the final version. Submission of an abstract for an AGU meeting is presumed to carry with it permission for AGU to reproduce the abstract in all editions of *Eos* and in the programs and reports relating to the meeting. It is also presumed to permit the free copying of those abstracts. Although *Eos* is a copyrighted journal, authors are not requested to transfer copyright. Copyright, where it exists, will be reserved by the authors.

Submittal Information

Numbers refer to the items in the submittal-information block on the sample abstract.

1. Title of meeting.
2. Identification (abstracts not authored by a member of AGU or of one of the cosponsoring societies must be sponsored by such a member; this includes invited authors): Type name of society to which any of the authors belong, or if no author is a member, type the name of the society to which the sponsor belongs (indicated by XXXX on the submittal information block) and the sponsor's name.
3. Corresponding address: Give complete address and phone number of author to whom all correspondence (acknowledgment and acceptance letters) should be sent. Abbreviate as much as possible.
4. Discipline to which abstract is submitted (use the following letter abbreviations): A (Atmospheric Sciences); B (Biological Oceanography); C (Chemical Oceanography); G (Geological Oceanography); O (Ocean Technology); P (Physical Oceanography); S (Acoustical Oceanography); X (Other).
5. Type title of special session (if any) to which submittal is made.
6. Indicate your preference for a particular kind of presentation by one of the following letters: O, oral; P, poster. The chairman may assign you to either of these types of presentation in order to fit his or her program plan.
7. Percent of material previously presented or published, and where.
8. Billing information.
   (*a*) Complete billing address if other than the corresponding address (item 3 above).
   (*b*) If purchase order is to be issued, indicate number upon submittal of abstract.
   (*c*) If a student member is the first author, the student publication rate is applicable. Indicate student rate applicable.
   (*d*) If prepaid, enter amount enclosed.
9. Indicate whether paper is C (contributed) or I (invited). If invited, list name of inviter.

Poster Sessions

A large, centrally located meeting room will be set up for poster presentations. Experience from recent AGU meetings and from other scientific societies has shown that a poster presentation, while more demanding of the author, can provide a superb opportunity for comprehensive discussions of research results. If individual papers are deemed by a program chairman to be suitable for this type of presentation, they may be so assigned.

Presenters of poster papers are reminded that a poster exhibit requires careful preparation. Figures and text will be scrutinized in detail, and authors must be prepared to discuss the contents of their papers in depth. Under these conditions, well-prepared figures and concise, logical text are essential.

Program Committee

Meeting Cochairmen John R. Apel, Johns Hopkins University, and Richard T. Barber, Duke University

AMS James J. O'Brien, Florida State University
ASA Robert S. Winokur, ONR
ASLO Mary Jane Perry, University of Washington
MTS Ned A. Ostenso, NOAA

Special Sessions

- Warm Core Rings
- Air–Sea Interaction in Coastal Regions
- Shelf Dynamics; CODE
- Optical Dynamics Experiment
- Marginal Ice Zone Experiment
- California Current
- Gulf of Mexico/Caribbean: Biological, Chemical and Physical Oceanography
- Southern Oceans: Dynamics, Biomass
- Kuroshio
- Arctic Ocean: Dynamics, Biology, Acoustics
- Seafloor Spreading Centers
- El Niño and Climate Variability
- El Chichón, Global Climate, Chemistry
- Oceans and Atmospheric Chemistry: CO_2, N_2, Freons
- Ocean Heat Transport: Climate, Paleoclimate
- Acoustic Monitoring: Suspended Particulates, Biology
- Acoustic Remote Sensing: Fine Structure, Internal Waves, Mesoscale Features
- Acoustic Imaging: Sea Floor, Precision Bathymetry
- Acoustic Tomography
- Large Scale Ocean Observing Systems
- SAR Surface Signatures
- Ocean Tracers
- Radioactive Disposal
- Environment and Fisheries Year Class Survival
- Zooplankton Behavior
- Plankton Growth Rates in Oligotrophic Waters
- Below Ground Processes in Wetland Ecosystems
- Phytoplankton Responses to Fluctuating Environments
- Aquatic Nitrogen Cycles
- Interrelation of Optical and Biological Properties
- Dynamics of Microaggregates in Oceanic Systems
- Organism Growth and Behavior in a Turbulent Fluid
- Biology and Physics of the Benthic Boundary Layer
- Feeding Ecology of Fishes
- Cyanobacteria: What are They Doing?

Sample Abstract

11.8cm

18 cm

Technique for the Preparation of Abstracts

F. R. S. T. AUTHOR (School of Oceanography, Hydro University, Watertown, Mass. 02172)
S. C. N. D. AUTHOR (USGS, Woods Hole, Mass. 02543) (Sponsor: I. C. Alvin)

Follow this example in typing the abstract. The printing plates will be prepared by photographing the abstracts exactly as they are received, except that abstracts exceeding the maximum length (18 cm) or width (11.8 cm) will be cut to conform.

Use a good typewriter with a ribbon in good condition. A carbon ribbon gives the best results. Please use type of about this size. Use 12 pitch. There will be a reduction of 50% for the printed abstract volume.

Follow these guidelines:

(1) Type title in capital and lower case letters except where all capitals are standard. Underscore entire title.
(2) Leave one line blank after title.
(3) Type names of authors in all capital letters, with affiliation and address in capital and lower case letters. Do not leave blank lines between authors.
(4) Underscore the name of author who will present paper.
(5) If no author is a member of a cosponsor society, type sponsor's name in capital and lower case letters.
(6) Leave one blank line after author block.
(7) Neatly drawn in symbols or Greek letters are acceptable. Use India ink.
(8) Use SI units.

NOTE: There are no special forms distributed for typing abstracts. You may trace this form in nonreproducible ink. Please leave at least 4 cm between top edge of paper and abstract title. Type abstract as close as possible to left edge of paper.

Submittal Information

(See explanation)

1. Ocean Sciences Meeting
2. AGU, ASLO, MTS, OES, AHS or ASA
   or
   XXXX (sponsor's name)
3. (a). Corresponding address:
   S.C.N.D. Author
   MS 123
   USGS
   Woods Hole, MA 02543
   (b). Telephone number
   617-548-1234
4. A (Atmospheric Science)
5. Special Session:
   Deep-Sea Drilling
   (or none)
6. P (Poster)
7. 10% at AGU Spring Meeting
8. (a). Hydro Univ.
   Accounting Dept.
   Admin. Bldg.
   Watertown, MA 02172
   (b). P.O. #5684739
   (c). Student rate applicable
   (d). If prepaid enter amount enclosed. (P.O.'s requiring invoicing are not eligible for discount rate)
9. C (Contributed)

Abstract Deadline: October 19, 1983

Mail original and two copies to

Ocean Sciences Meeting

American Geophysical Union
2000 Florida Avenue, N. W.
Washington, D. C. 20009